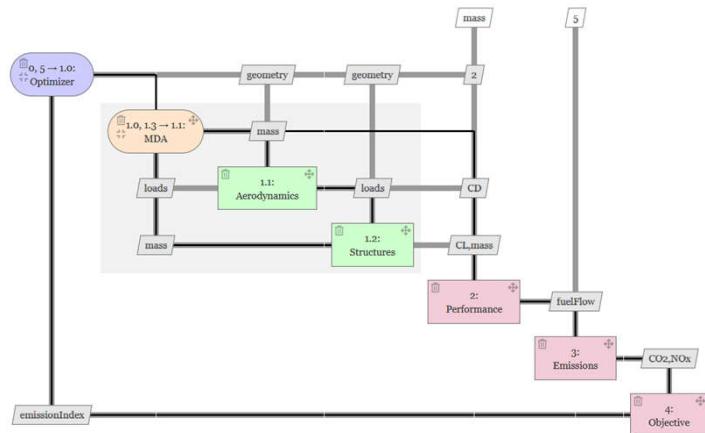
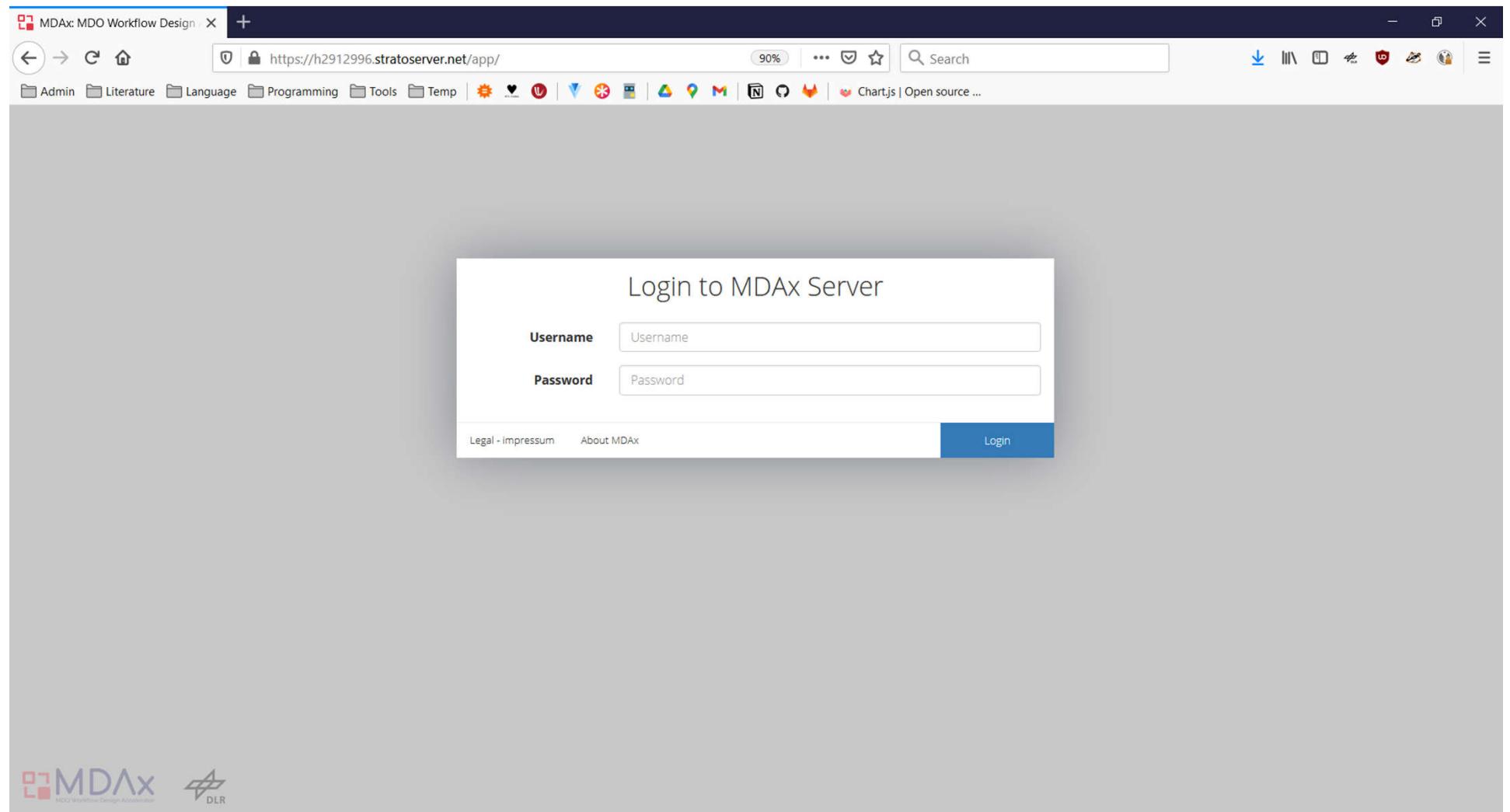


MDAx Step-by-Step Example

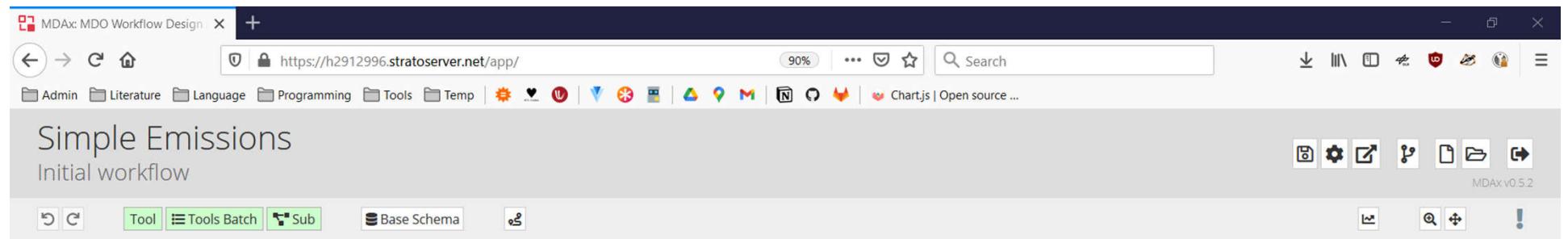


Knowledge for Tomorrow



Use your username and password to log in.



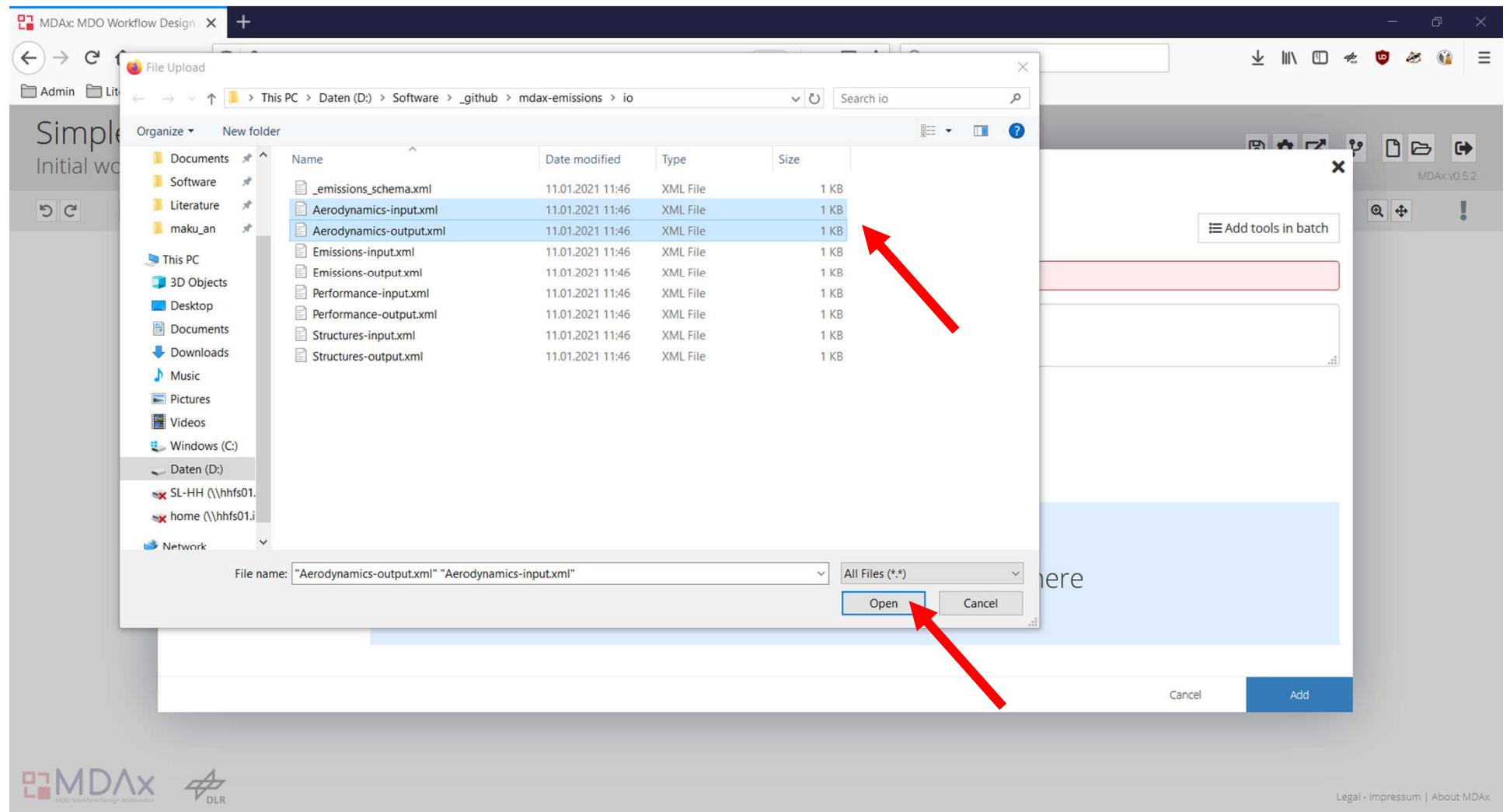


To add single tools using its input/output (I/O) definition, click on the dashed block in the center or the *Tool* button in the toolbar.

The screenshot shows a web browser window with the URL <https://h2912996.stratoserver.net/app/>. The page title is "MDAx: MDO Workflow Design". The main content area displays a workflow titled "Simple Emissions" with the sub-tittle "Initial workflow". A modal dialog box is open, titled "Add Disciplinary Analysis Tool". Inside the dialog, there are fields for "Function name" (labeled "Tool Name required"), "Notes", "Tool version", and an "I/O Definition" section with a placeholder "Upload I/O XML files: click or drag here". At the bottom right of the dialog are "Cancel" and "Add" buttons. Red arrows highlight the "Tool Name required" label and the "Upload I/O XML files" area.

Set the name for your tool and click on the blue are to select the I/O definition.
If you prefer MDAX to automatically detect the tool name from the definition
files, leave the name field empty.





Select one input and one output definition file, and click *Open*.

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp | 🚧 ❤️ ⚡ 📈 🌐 📉 🎨 📈 🌐 🎨 Chart.js | Open source ...

Simple Emissions
Initial workflow

Add Disciplinary Analysis Tool

Tool Name: Aerodynamics

Notes:

Tool Version: Tool version

I/O Definition: Selected file: Aerodynamics-input.xml
Selected file: Aerodynamics-output.xml

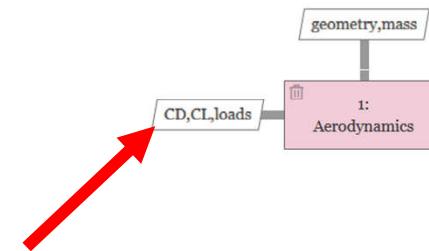
Cancel Add

MDAx v0.5.2

The input and output files are imported and listed in the menu. Click Add to proceed.



The screenshot shows the MDAX MDO Workflow Design application interface. At the top, there's a browser-like header with tabs, a search bar, and various system icons. Below the header is a toolbar with icons for Admin, Literature, Language, Programming, Tools, Temp, and several others. The main area is titled "Simple Emissions" and "Initial workflow". It contains a workflow diagram with nodes like "geometry,mass", "CD,CL,loads", and "Aerodynamics". A red arrow points to the "CD,CL,loads" node. The bottom of the screen features the MDAX logo and navigation links for Legal, Impressum, and About.



To inspect the inputs and outputs of your imported tool, click on the *variable blocks*, or click on the tool block...

MDAx: MDO Workflow Design

https://h2912996.stratoserver.net/app/

Admin Literature Language Programming Tools Temp | Chart.js | Open source ...

Simple Emissions

Edit Disciplinary Analysis Tool

Tool Name: Aerodynamics

Notes:

Tool Version: Tool version

Upload the XML files specifying the input and output of the disciplinary analysis tool.
The input file should contain "input" in its file name, the output file should contain "output".
It is possible to only upload one of the two, or not upload any at all.

I/O Definition

Upload I/O XML files: click or drag here

Cancel Update

...and in the tool window, click the *input* or *output* button.



The screenshot shows the MDAX MDO Workflow Design application interface. A central dialog box is titled "Output Variables" and contains a pink header box labeled "1: Aerodynamics". Below this is a tree view under "Search: xpath" with the following structure:

- schema
- aircraft
- wings
- wing
 - mass
 - geometry
 - CL
 - loads
 - CD

To the right of the tree view are several rows of icons for managing variables, including edit, add, and delete symbols. At the bottom of the dialog is a large blue button labeled "Upload I/O XML files: click or drag here". At the very bottom are "Cancel" and "Update" buttons.

The background of the application shows a sidebar with sections for "Tool Name", "Notes", "Tool Version", and "I/O Definition". The "I/O Definition" section has a placeholder text "Upload I/O XML files: click or drag here". The top of the screen shows a browser-like header with tabs, a search bar, and various system icons.

This opens the variable tree that shows the inputs or outputs of that tool.

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp | Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

MDAx v0.5.2

Simple Emissions
Initial workflow

geometry, mass

CD, CL, loads 1: Aerodynamics

To add multiple tools at once, click *Tool Batch*.

MDAx: MDO Workflow Design X +

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Admin Literature Language Programming Tools Temp | 🔥 ❤️ 🚀 ⚡ 📈 🌐 📉 🎨 📈 🎨 📈 🎨 Chart.js | Open source ...

Simple Emissions

Initial workflow

MDAx v0.5.2

Opt DoE Conv Tool Tools Batch Sub Vars Base Schema

Batch Add Disciplinary Analysis Tools

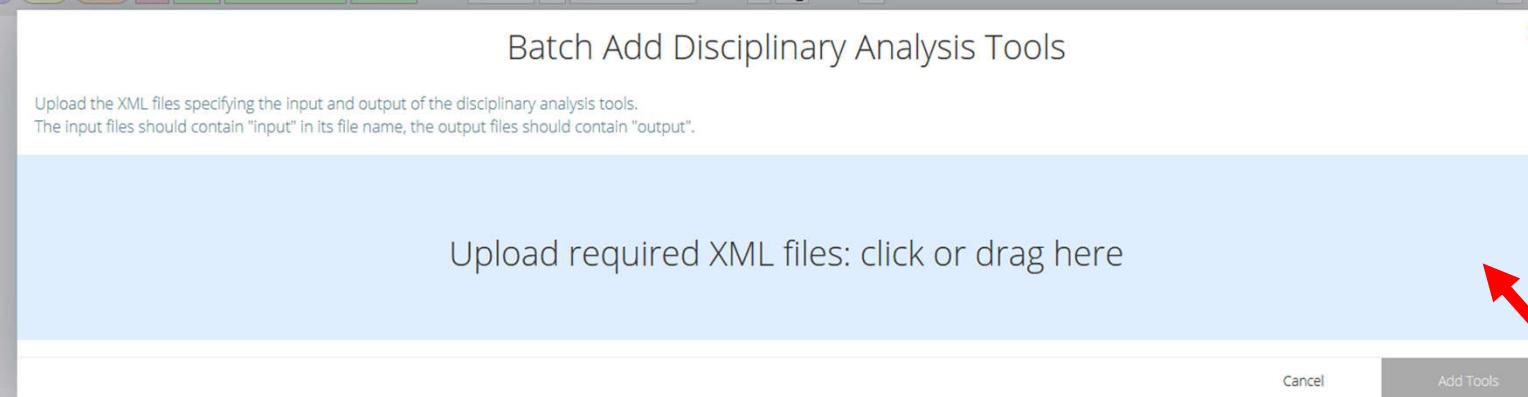
Upload the XML files specifying the input and output of the disciplinary analysis tools.
The input files should contain "input" in its file name, the output files should contain "output".

Upload required XML files: click or drag here

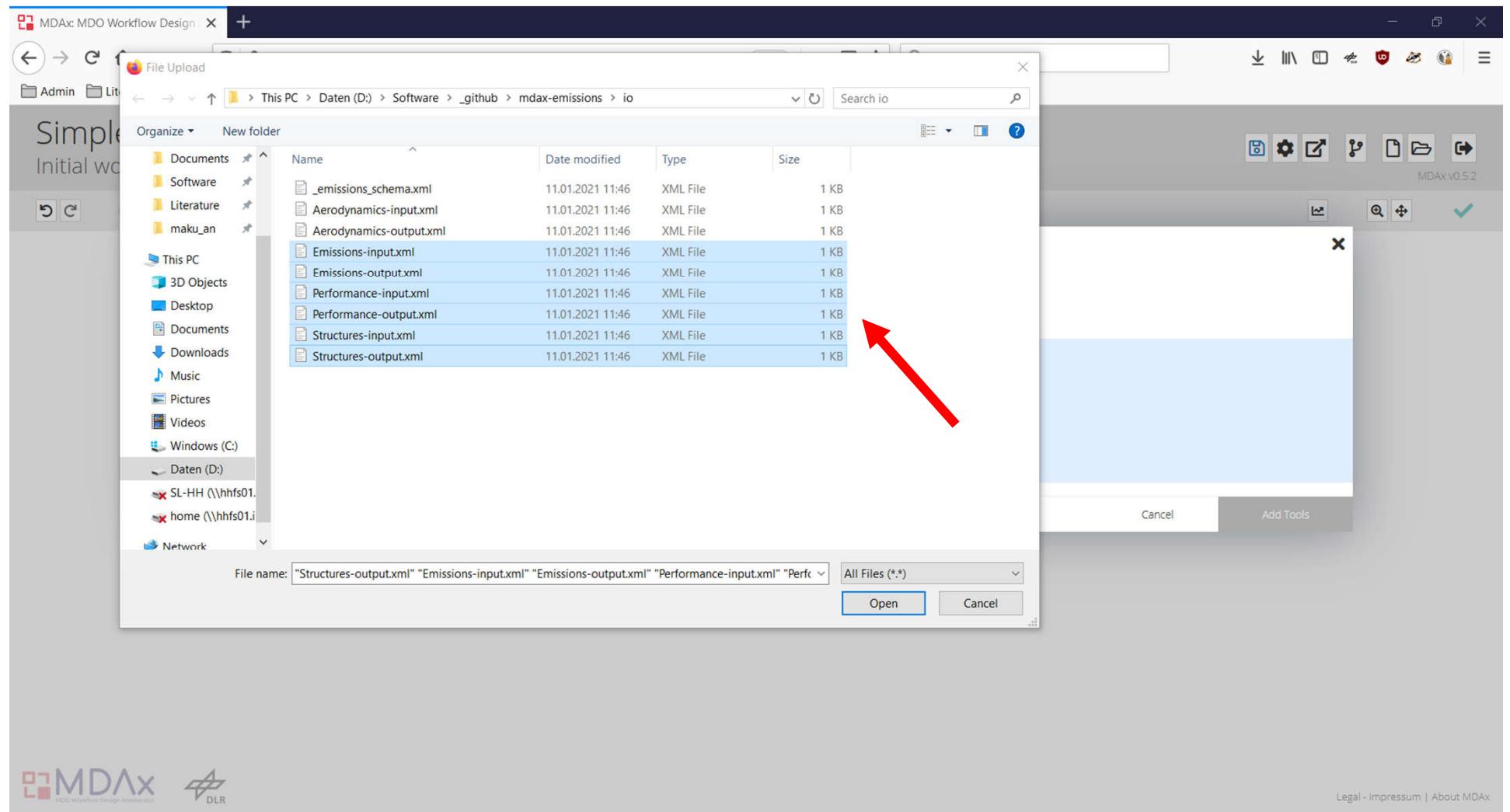
CD,CL,loads 1: Aerodynamics

Cancel Add Tools

MDAx MDO Workflow Design Application DLR Legal - Impressum | About MDAx



As with the single tool, click the blue area...



...and select the input and output definitions for the tools you would like to add. Here, you can select multiple files for import...

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp | Chart.js | Open source ...

Simple E Initial workflow

Batch Add Disciplinary Analysis Tools

Upload the XML files specifying the input and output of the disciplinary analysis tools.
The input files should contain "input" in its file name, the output files should contain "output".

Selected file: Emissions-input.xml
Selected file: Emissions-output.xml
Selected file: Performance-input.xml
Selected file: Performance-output.xml
Selected file: Structures-input.xml
Selected file: Structures-output.xml

Upload required XML files: click or drag here

Use the table below to link the uploaded input/output files to tools to be created.
It is possible to create tools which only have either input or output.

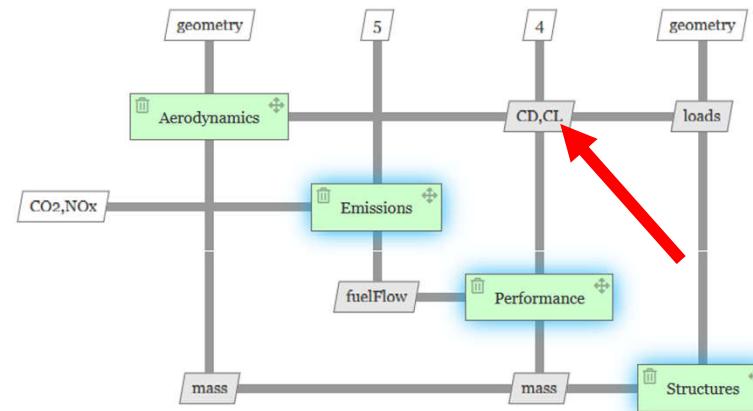
Tool Name	Input File	Output File	Actions
Emissions	Emissions-input.xml	Emissions-output.xml	[Delete]
Performance	Performance-input.xml	Performance-output.xml	[Delete]
Structures	Structures-input.xml	Structures-output.xml	[Delete]
Tool name			[Add]

Cancel Add Tools

MDAx MDO Workflow Design Application DLR Legal - Impressum | About MDAX

...and MDAx automatically recognizes the tool name based on the file naming convention *[tool name]-[input/output].[extension]*. Click *Add Tools* to add the selected tools to the canvas.

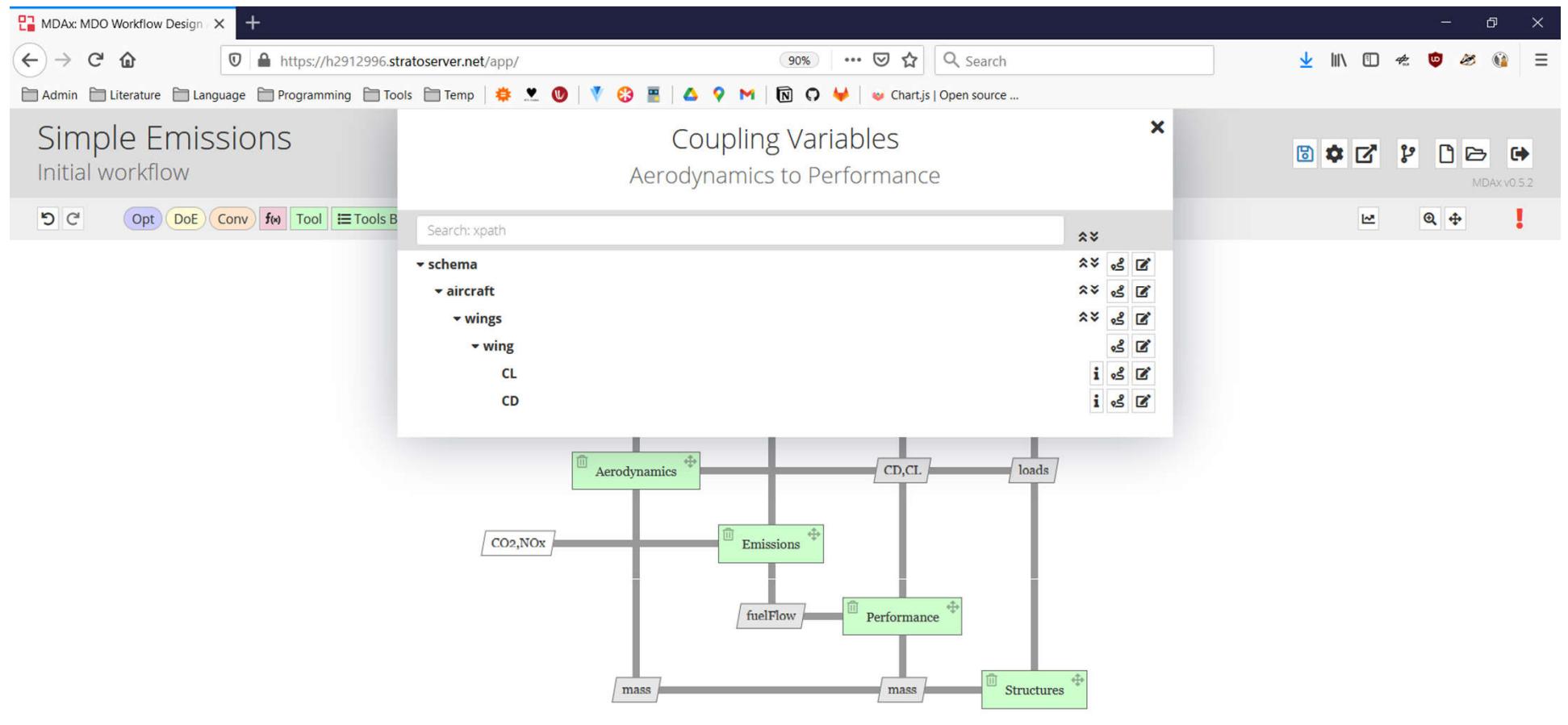
The screenshot shows a browser window titled "MDAx: MDO Workflow Design". The URL is https://h2912996.stratoserver.net/app/. The page content displays a "Simple Emissions" workflow with the title "Initial workflow". The interface includes a top navigation bar with links like Admin, Literature, Language, Programming, Tools, Temp, and various icons for file operations and system status. A bottom toolbar contains buttons for Opt, DoE, Conv, Tool, Tools Batch, Sub, Vars, Base Schema, and other workflow management functions. The footer indicates the version is MDAx v0.5.2.



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Now that multiple tools are added, you can inspect the connections between them by clicking on the parameter blocks.





The variable tree show which parameters are exchanged between the two tools.

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

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Simple Emissions

Initial workflow

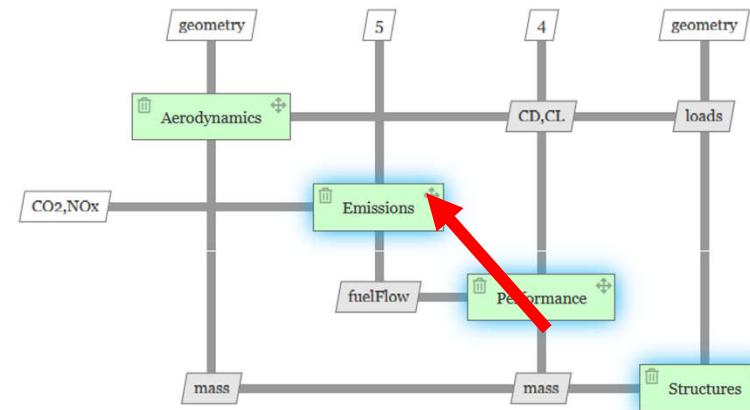
MDAx v0.5.2

Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Vars Base Schema

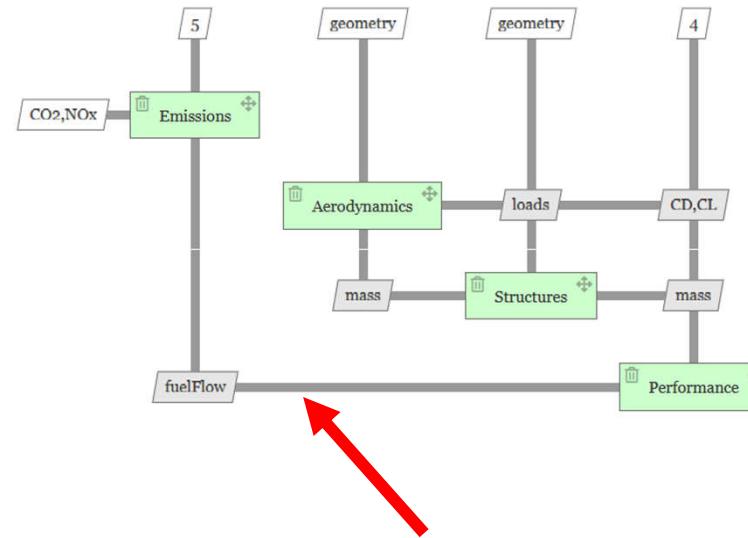
MDAx v0.5.2

The screenshot shows a workflow diagram titled "Simple Emissions" under "Initial workflow". The diagram consists of several tool blocks connected by arrows: Aerodynamics, CD,CL, loads, Emissions, Performance, and Structures. Inputs include geometry, 5, 4, CO2,NOx, fuelFlow, and mass. A red arrow points to the "Emissions" block.



You can drag and drop tool blocks using the icon in its top-right corner.

The screenshot shows the MDAx: MDO Workflow Design application window. The title bar reads "MDAx: MDO Workflow Design". The top navigation bar includes standard browser controls (back, forward, search, etc.) and a URL bar showing "https://h2912996.stratoserver.net/app/". Below the URL bar is a toolbar with various icons for file operations like Admin, Literature, Language, Programming, Tools, Temp, and a set of small red, green, and blue icons. A search bar labeled "Search" is also present. The main content area features a large title "Simple Emissions" and a subtitle "Initial workflow". On the right side of the content area are several large, light-blue square buttons with icons. At the bottom of the screen is a toolbar with various tool icons, including "Opt", "DoE", "Conv", "Tool", "Tools Batch", "Sub", "Vars", "Base Schema", and other smaller icons. The bottom right corner displays the text "MDAx v0.5.2".



MDAx
MDA National Data Processor Association

Legal - Impressum | About MDAX

Notice that forward and feedback connections change depending on the position of the tool in the workflow sequence. The sequence always goes from left to right.



For complex workflows with many tools, MDAx offers a sorting algorithm that sorts the workflow sequence to minimize feedback connection. Click the *Auto Sort* button, ...



MDAx: MDO Workflow Design X + https://h2912996.stratoserver.net/app/ 90% ... Search Admin Literature Language Programming Tools Temp | Chart.js | Open source ... Simple Emissions Initial workflow

Automated Function Sorting

Select Sorting Algorithm

Current function order
 Partitioning

Moves independent functions to the front, functions without output to the end, and groups independent loops. This algorithm works well for basic function positioning, but does not sort functions within a loop.

Preview

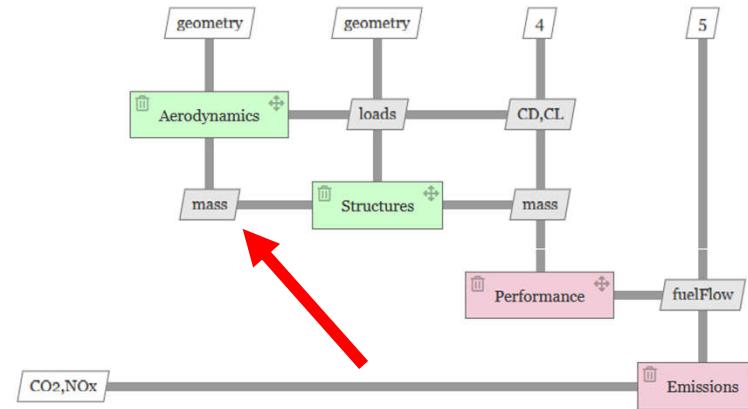
```
graph LR; geometry1[geometry] --> Aerodynamics[Aerodynamics]; Aerodynamics --> mass1[mass]; Aerodynamics --> loads[loads]; loads --> structures[Structures]; structures --> mass2[mass]; structures --> performance[Performance]; performance --> fuelFlow[fuelFlow]; fuelFlow --> emissions[Emissions]; CO2NOx[CO2,NOx] --> emissions; 4[4] --- CDCL[CD,CL]; 5[5] --- Emissions; style Aerodynamics fill:#90EE90,stroke:#3CB371,color:#3CB371; style structures fill:#90EE90,stroke:#3CB371,color:#3CB371; style performance fill:#90EE90,stroke:#3CB371,color:#3CB371; style Emissions fill:#90EE90,stroke:#3CB371,color:#3CB371;
```

Cancel Apply Sorting

MDAx v0.5.2

...select the the *Partitioning* option, and continue with *Apply Sorting*.

The screenshot shows a browser window titled "MDAx: MDO Workflow Design". The URL is https://h2912996.stratoserver.net/app/. The page content displays a "Simple Emissions" workflow with the title "Initial workflow". The interface includes a top navigation bar with links like Admin, Literature, Language, Programming, Tools, Temp, and various icons for file operations and system status. A bottom toolbar contains buttons for Opt, DoE, Conv, Tool, Tools Batch, Sub, Vars, Base Schema, and other workflow management functions. The footer indicates the version is MDAx v0.5.2.



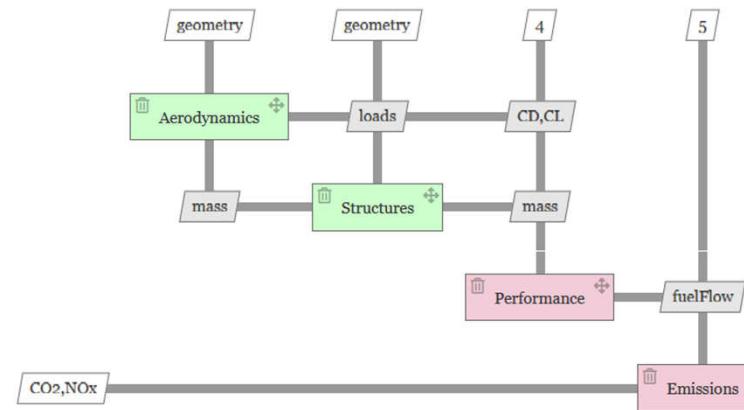

MDAx
MDA Multidisciplinary Advanced Systems


[Legal - Impressum](#) | [About MDax](#)

The resulting workflow will have a minimum amount of feedback connections.



The screenshot shows a browser window titled "MDAX: MDO Workflow Design". The URL is https://h2912996.stratoserver.net/app/. The page content displays a "Simple Emissions" workflow with a single step labeled "Initial workflow". On the right side of the workflow, there is a toolbar with several icons: a blue square, a gear, a checkmark, a document, a file folder, and a right-pointing arrow. A red arrow points from the bottom right towards the "gear" icon. At the bottom of the screen, there is a navigation bar with various buttons like Opt, DoE, Conv, Tool, Tools Batch, Sub, Vars, Base Schema, and a search bar.



Legal - Impressum | About MDAx

To help with workflow versioning, you can create workflow branches by clicking on the *Project Tree* button.



MDAx: MDO Workflow Design x +

https://h2912996.stratoserver.net/app/ 90% ... Search Admin Literature Language Programming Tools Temp | Chart.js | Open source ... MDAX v0.5.2

Simple Emissions

Initial workflow

Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Project Branch Tree

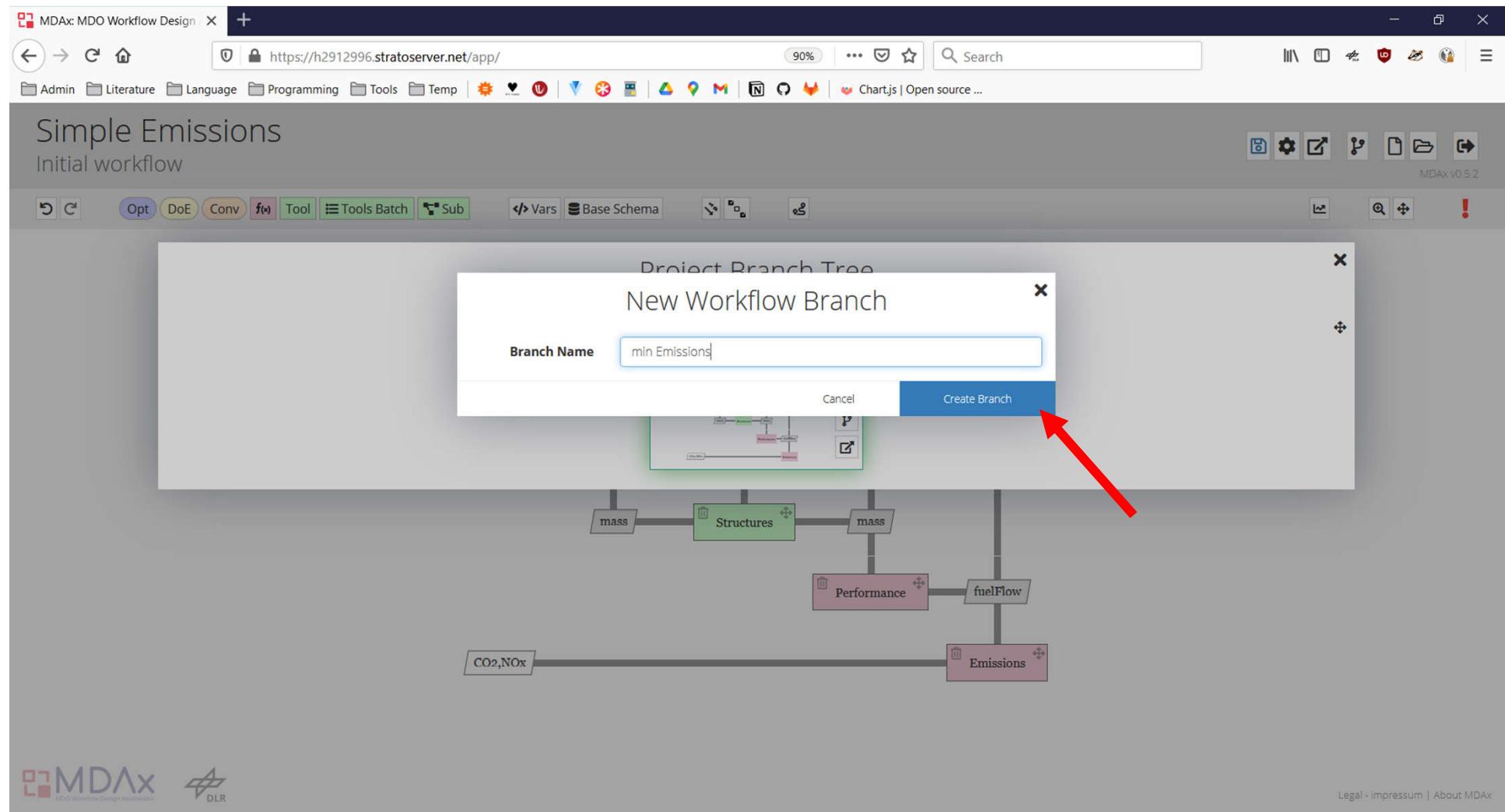
Simple Emissions

Initial workflow

The screenshot shows the MDAX interface with a project titled "Simple Emissions". A modal window titled "Project Branch Tree" displays the "Initial workflow". The workflow diagram consists of several nodes: "mass" (grey), "Structures" (green), "mass" (grey), "Performance" (pink), "fuelFlow" (grey), "CO₂,NOx" (grey), and "Emissions" (pink). Arrows indicate data flow between these nodes. A red arrow points to the "Edit" icon (pencil) in the "Initial workflow" modal. The bottom part of the screen shows the main workspace with the same nodes and connections.

Here, click on the branching symbol of the workflow that you want to branch off from.





Define the new branch name and click *Create Branch*.

MDAx: MDO Workflow Design x +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp | Chart.js | Open source ...

Simple Emissions

Initial workflow

Project Branch Tree

Simple Emissions

Initial workflow

min Emissions

MDAx v0.5.2

This creates a derivative workflow that is based on the original workflow.



MDAx: MDO Workflow Design X +

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Admin Literature Language Programming Tools Temp | ... | Chart.js | Open source ...

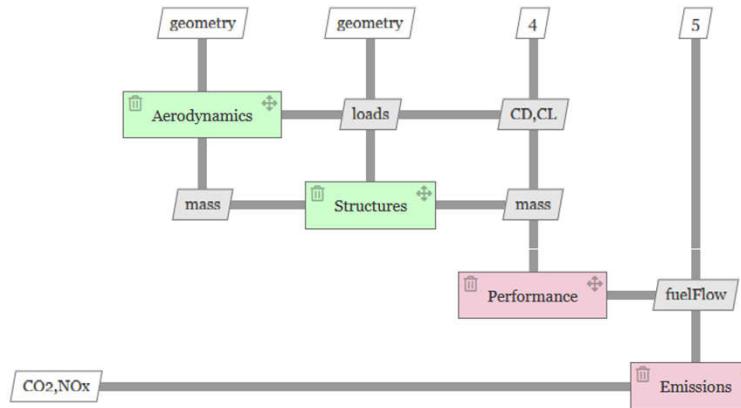
Simple Emissions

min Emissions

Opt DoE Conv Tool Tools Batch Sub Vars Base Schema

MDAx v0.5.2

The screenshot shows the MDAx interface with a workflow diagram titled "Simple Emissions". The current branch name "min Emissions" is highlighted with a red arrow. The workflow consists of several nodes connected by arrows: "geometry" (green) feeds into "Aerodynamics" (green), which then feeds into "Structures" (green). "Structures" feeds into "mass" (grey), which then feeds into "Performance" (pink). "Performance" feeds into "fuelFlow", which then feeds into "Emissions" (pink). "Emissions" outputs "CO2,NOx". There are also nodes "loads" (grey), "CD,CL" (grey), and "4" (grey) connected to the flow between Aerodynamics and Structures. The interface includes a toolbar with various icons and a status bar at the bottom.



The current branch name is visible in the menu bar. We can perform changes to this workflow without affecting its parent workflow. Multiple branches can be created in parallel.

MDAx: MDO Workflow Design X +

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Admin Literature Language Programming Tools Temp | ... | Chart.js | Open source ...

Simple Emissions

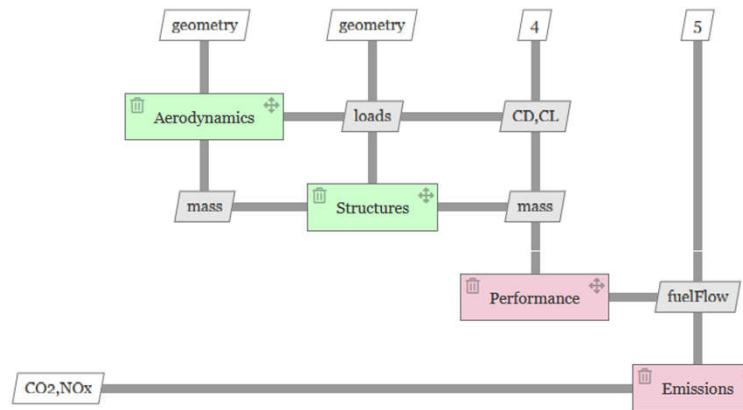
min Emissions

Opt Conv Tool Tools Batch Sub Vars Base Schema

MDAx v0.5.2

Remove unnecessary function

The screenshot shows the MDAx interface with a workflow diagram titled "Simple Emissions". The diagram consists of several nodes connected by arrows: "geometry" (green) feeds into "Aerodynamics" (green), which then feeds into "Structures" (green). "Structures" feeds into "mass" (grey), which then feeds into "Performance" (pink). "Performance" feeds into "fuelFlow", which then feeds into "Emissions" (pink). "Emissions" also receives input from "CO2,NOx" (grey). There are also connections from "geometry" to "loads" (grey), "loads" to "CD,CL" (grey), and "CD,CL" to "mass". Nodes are labeled with their names and some parameters (e.g., "4", "5"). A red arrow points to the "Remove unnecessary function" button in the toolbar.



In this branch, we can demonstrate the removal of redundant tools. Redundant tools are tools that are not necessary for the computation of the parameters of interest. Click the *Remove unnecessary function* button.

Here we can specify variables and tools to keep. Click on the *Select variables* button...



MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp Chart.js Open source ...

Simple Emissions

min Emission

Output variables to keep

Variable

Functions to keep

Function

Aerodynamics

Select Output Variables to Keep

Search: xpath or !selected

schema

aircraft

wings

wing

mass

CL

loads

CD

performance

fuelFlow

mission

emissions

CO2

NOx

Cancel Select Cancel Apply

The screenshot shows the MDAx interface with a modal dialog titled "Select Output Variables to Keep". The dialog displays a hierarchical schema structure for output variables. Under the "performance" section, the "fuelFlow" variable is selected, indicated by a checked checkbox. A red arrow points to this checkbox. The background of the main application window is visible, showing tabs like "Simple Emissions" and "min Emission", and a sidebar with sections for "Output variables to keep" and "Functions to keep".

...and select the variable(s) of interest.

MDAx: MDO Workflow Design X + https://h2912996.stratoserver.net/app/ 90% ... Search Admin Literature Language Programming Tools Temp | Chart.js | Open source ...

Simple Emissions

min Emission

Automatically Remove Unnecessary Functions

Settings

Output variables to keep

Variable	Actions
fuelFlow	
<input checked="" type="checkbox"/>	

Functions to keep

Function	Actions
Aerodynamics	

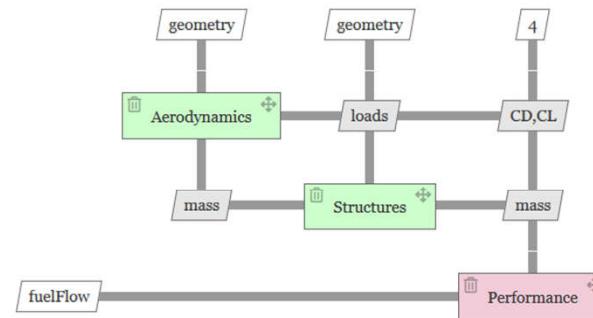
Preview

Cancel Apply

MDAx MDO Workflow Design Application DLR Legal - Impressum | About MDAx

MDAx makes a dependency analysis and automatically determines which tools it can remove. Click *Apply* to remove the highlighted tool(s). The same functionality can be applied to function blocks.

The screenshot shows a browser window titled "MDAx: MDO Workflow Design". The address bar contains the URL "https://h2912996.stratoserver.net/app/". The page content includes a navigation bar with links like "Admin", "Literature", "Language", "Programming", "Tools", "Temp", and several icons for file operations (e.g., upload, download, copy, paste). Below this is a section titled "Simple Emissions" with a sub-section "min Emissions". On the right side, there are icons for configuration, export, and other workflow management functions. At the bottom, there's a toolbar with buttons for "Opt", "DoE", "Conv", "Tool", "Tools Batch", "Sub", "Vars", "Base Schema", and "Help". The overall interface is clean and modern, designed for engineering and scientific workflow management.



Legal - Impressum | About MDAx

The redundant tool is removed from the workflow. This is especially convenient in large, complex workflows. The user can import his entire tool repository and quickly determine which tools can be dropped.



The screenshot shows the MDAX: MDO Workflow Design application interface. At the top, there's a navigation bar with links like Admin, Literature, Language, Programming, Tools, Temp, and various system icons. The main title is "Simple Emissions". Below it, a "Project Branch Tree" section shows a tree structure for "Simple Emissions". A red arrow points from the "Initial workflow" icon to a workflow editor window below. This editor window has a green border and displays a simplified version of the workflow, with a "min Emissions" label above it. The bottom right corner of the editor window contains the text "MDAX v0.5.2".

Return to the original workflow.



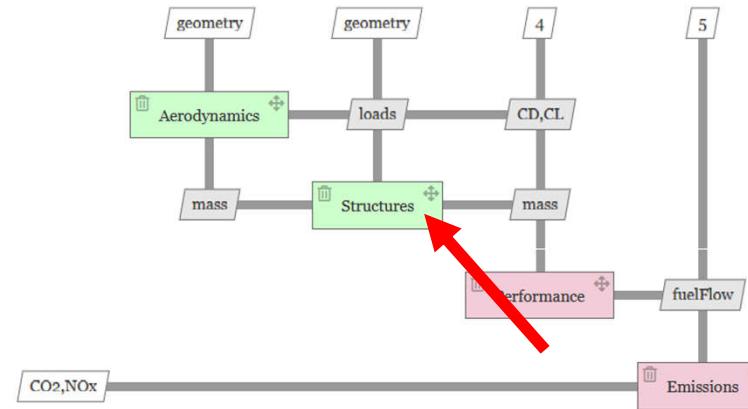
Here you can see that you can not edit it, because it has downstream branch dependency. Click *Start editing* ...



To create a copy of the workflow in another branch. Select it to continue working.



The screenshot shows a browser window titled "MDAx: MDO Workflow Design". The URL is https://h2912996.stratoserver.net/app/. The page content displays a "Simple Emissions" workflow with the title "Initial workflow". The interface includes a top navigation bar with links like Admin, Literature, Language, Programming, Tools, Temp, and various icons for file operations and system status. A bottom toolbar features buttons for Opt, DoE, Conv, Tool, Tools Batch, Sub, Vars, Base Schema, and other workflow management functions. The footer indicates the version is MDAx v0.5.2.



MDAx
MDA Multidisciplinary Advanced Research

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In many workflows, variable collisions exist. Colliding variables are provided by more than one tool, and required by at least one other tool. The user has to clarify this ambiguity. To add a collision, click on the *Structures* block...



The screenshot shows a web-based application interface for MDAx: MDO Workflow Design. The main title bar reads "MDAx: MDO Workflow Design". The browser address bar shows the URL "https://h2912996.stratoserver.net/app/". The page content is titled "Simple Emissions" and "Initial workflow". A central modal dialog box is open, titled "Edit Disciplinary Analysis Tool". Inside the dialog, there are three buttons at the top: "View / edit input" (disabled), "Structures" (highlighted in green), and "View / edit output". Below these buttons are three form fields: "Tool Name" (set to "Structures"), "Notes" (empty), and "Tool Version" (empty). A note below the fields instructs users to upload XML files for input and output definitions. A large blue area labeled "Upload I/O XML files: click or drag here" is provided for file uploads. At the bottom right of the dialog are "Cancel" and "Update" buttons. A red arrow points to the "View / edit output" button. The status bar at the bottom right of the screen displays "MDAx v0.5.2".

...and edit the tool output.



The screenshot shows the MDAX MDO Workflow Design application interface. The main window title is "MDAx: MDO Workflow Design". The URL in the browser is <https://h2912996.stratoserver.net/app/>. The page content is titled "Simple Emissions" and describes it as an "Initial workflow". On the left, there are sections for "Tool Name", "Notes", "Tool Version", and "I/O Definition". The "I/O Definition" section is expanded, showing a tree view of schema elements: schema > aircraft > wings > wing. Under "wing", there are entries for "mass", "geometry", "CL", "loads", and "CD". Other collapsed categories include "fuselage", "empennage", "performance", "fuel", and "mission". To the right of the tree view is a "Output Variables" dialog. This dialog has a "Structures" tab selected. It contains a search bar labeled "Search: xpath" and a list of variables. The "CL" variable is highlighted with a red arrow pointing to its "link" icon (a circular arrow symbol) in the toolbar. At the bottom of the dialog are "Cancel" and "Update" buttons.

In the tree view, add an existing variable such as *CL* by clicking the *link* symbol.

MDAx: MDO Workflow Design x +

https://h2912996.stratoserver.net/app/ 90% ... Search Admin Literature Language Programming Tools Temp | Chart.js | Open source ...

Simple Emissions

Initial workflow

Tool Name Notes Tool Version I/O Definition

Output Variables

Structures

Search: xpath

schema

- aircraft
 - wings
 - wing
 - mass
 - geometry
 - CL
 - loads
 - CD
 - fuselage
 - empennage
 - performance
 - fuel
 - mission

MDAx v0.5.2

Cancel Update

Added CL to Structures output

MDAx MDO Workflow Design Add-on

DLR

This adds the CL parameters to the tool outputs, marked red to indicate that a variable collision exists on this parameter.



MDAx now indicates that there are issues with collisions.



MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

Admin Literature Language Programming Tools Temp ... Chart.js Open source ...

Simple Emissions Initial workflow

Opt DoE Conv f(x) Tool Tools B

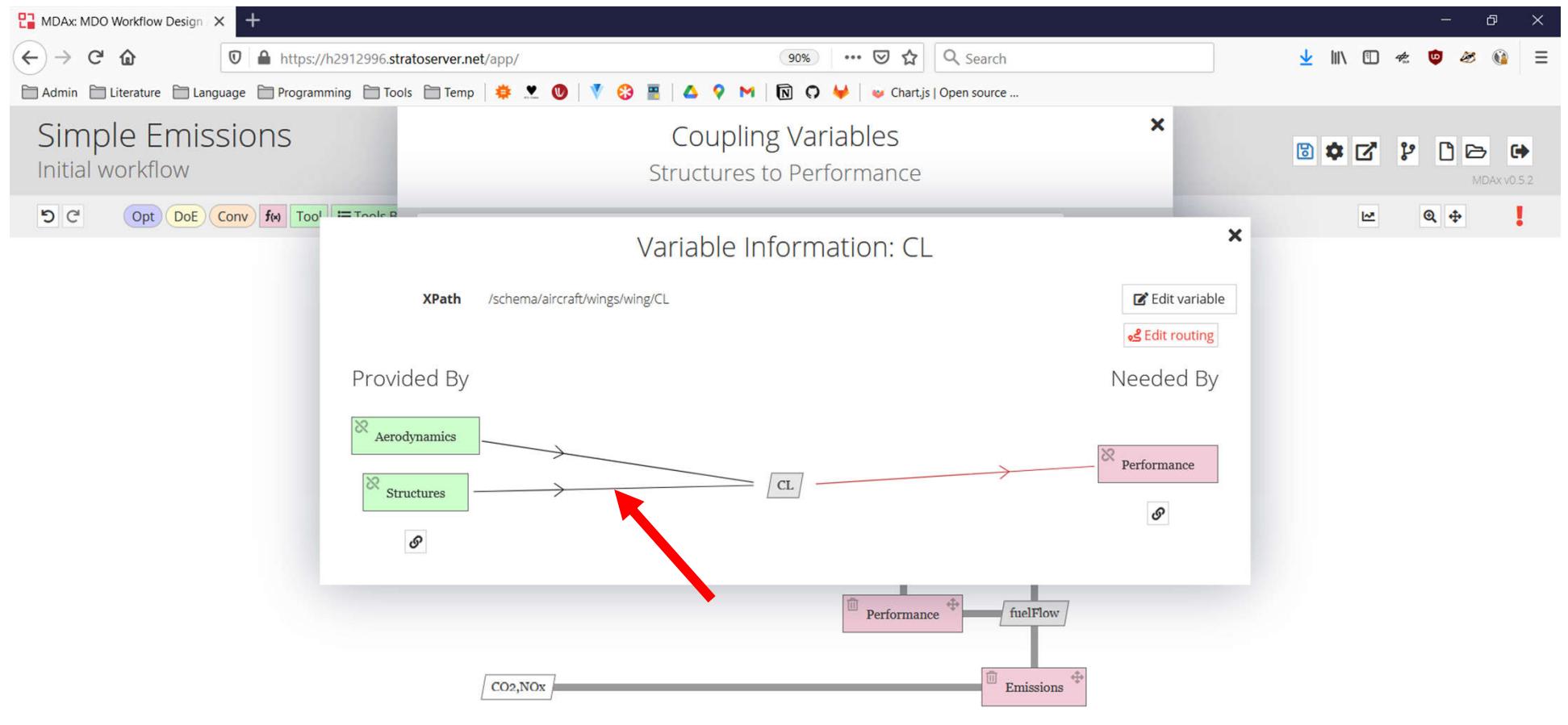
Coupling Variables Structures to Performance

Search: xpath

schema
aircraft
wings
wing
mass
CL

The screenshot shows the MDAx interface with a workflow titled "Simple Emissions" and "Initial workflow". The workflow consists of four main nodes: "Aerodynamics" (green), "Structures" (green), "Performance" (pink), and "Emissions" (pink). "Aerodynamics" provides "mass" and "CL". "Structures" provides "mass" and "CL, mass". "Performance" requires "CL" and "fuelFlow". "Emissions" requires "CO2, NOx". A red arrow points from the "Edit routing" button in the variable tree to the "CL" connection between Aerodynamics and Performance.

Looking at the tool connections, it is clear that *Aerodynamics* and *Structures* both provide *CL*, while *Performance* requires it. To manually resolve this ambiguity, click on the *Edit routing* button in the variable tree.



By clicking on the connection, you can manually remove it.

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/ 90% ... Search

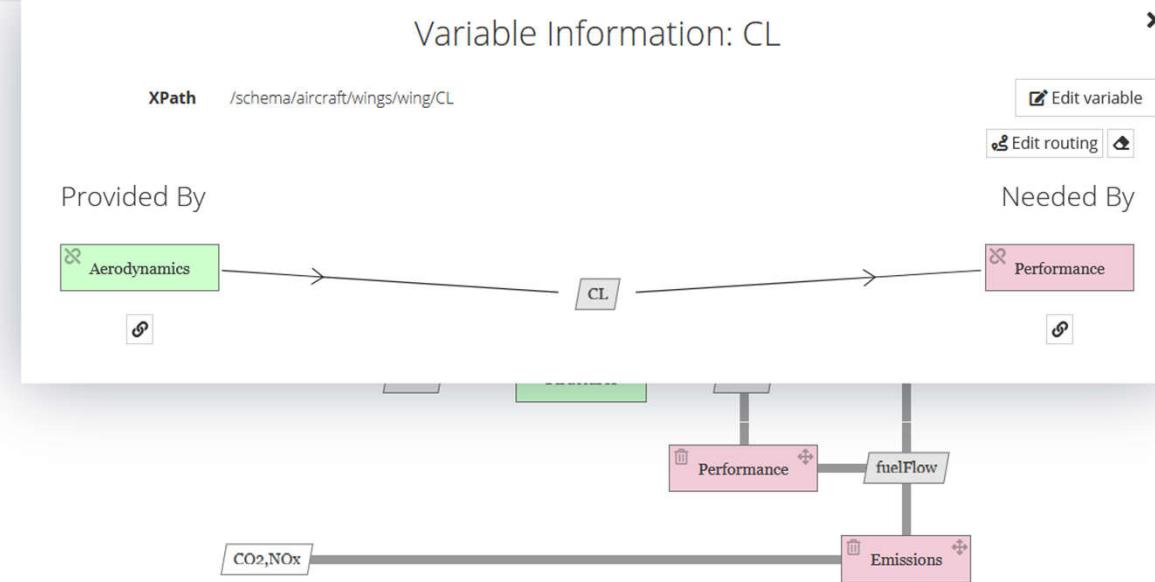
Admin Literature Language Programming Tools Temp ⚡ ❤️ 🔍 📈 🌐 📉 🎨 🖤 🖥️ Chart.js | Open source ...

Simple Emissions Initial workflow

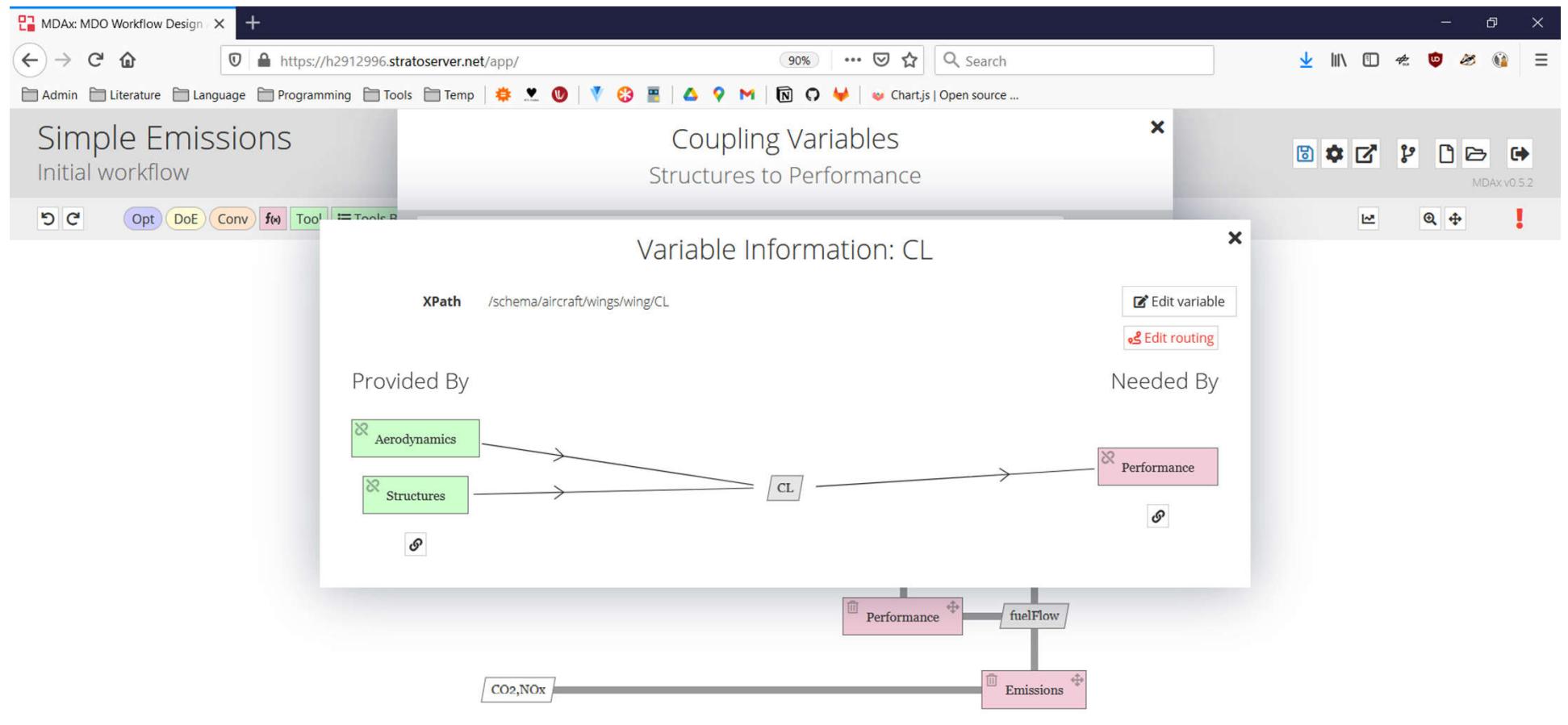
Coupling Variables Structures to Performance

MDAx v0.5.2

Opt DoE Conv Fix Tool Tools B Search: xpath



Press **CRTL-Z** (or click the *Undo* button) to undo this.



Alternatively, you can enter the *Variable Routing* view to resolve collisions. For this, click this *Edit routing* button.

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/schema/aircraft/wings/wing/CL

Simple Emissions
Initial workflow

Opt DoE Conv fwi Tools

Connection rules:

- Click on a providing, then on a needing function to create a connection
- Click on an arrow to remove the connection

Provided By

Needed By

O:
System input

Aerodynamics

Structures

Performance

Feedback

Feedforward

Cancel Apply

MDAx v0.5.2

Legal - Impressum | About MDAx

The screenshot shows a connection diagram within the MDAx interface. On the left, under 'Provided By', there are two green boxes: 'Aerodynamics' and 'Structures'. On the right, under 'Needed By', there is a pink box labeled 'Performance'. A red arrow points from 'Aerodynamics' to 'Performance'. Below the diagram are two large red arrows: one pointing upwards labeled 'Feedback' and one pointing downwards labeled 'Feedforward'. At the bottom of the interface are 'Cancel' and 'Apply' buttons. The top right corner displays the version 'MDAx v0.5.2'.

Here, click on the source and sink of the connection.

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Simple Emissions

Initial workflow

Provided By

Needed By

O: System input

Aerodynamics

Structures

Performance

Feedback

Feedforward

Connection rules:

- Click on a providing, then on a needing function to create a connection
- Click on an arrow to remove the connection

/schema/aircraft/wings/wing/CL

MDAx v0.5.2

Cancel Apply Legal - Impressum | About MDAX

```
graph LR; O[O: System input] --> Aerodynamics[Aerodynamics]; O --> Structures[Structures]; Aerodynamics --> Performance[Performance];
```

This creates a connection for that variable between the selected tools. MDAx disallows connections that introduce further ambiguities. Play around with it to develop a feeling.

Return to the canvas view and find that the collision has been resolved. Press **CTRL-Z** again to return to the earlier state with the collision in place.



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Simple Emissions

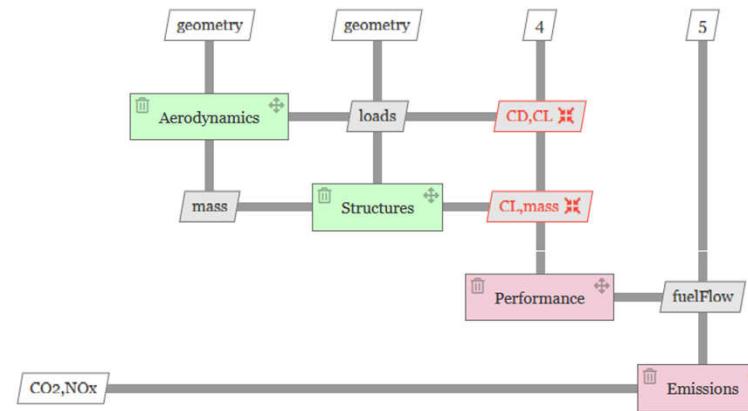
Initial workflow

MDAx v0.5.2

Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Variables Settings

Red arrow pointing to the "Variables Settings" button.



An alternative way to resolve collisions is to use the automatic collision resolution algorithms. Click the *Variable Routing Settings* button...

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Simple Emissions

Initial workflow

Variable Routing Settings

Automated variable routing methods solve **collisions**: two or more functions writing to the same variable.

Latest variable

Each function receives the *latest available* version of the variable. The last globally available version is finalized back once to all tools.

Closest variable

Each function receives the *closest available* version of the variable.

Latest-Closest variable

Each function receives the closest available version of the variable, while taking the *latest available* for sequential outputting functions.

Example Result

Cancel Apply

CO₂,NOx Emissions

MDAx MDO Workflow Design Acceleration DLR Legal - Impressum | About MDAx

...and select one of the possible algorithms to resolve collisions. Each algorithm works slightly different, possibly resulting in different workflow connections. The selected algorithm is applied to all outstanding collisions. Click **Apply**.



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Simple Emissions

Initial workflow

Opt DoE Conv Tool Tools Batch Sub Vars Base Schema

MDAx v0.5.2

Workflow has unconverged feedback connections. Solve this by adding convergers, or by breaking feedback connections.

The screenshot shows the MDAX interface with a workflow diagram titled "Simple Emissions". The diagram consists of several nodes connected by arrows: "geometry" feeds into "Aerodynamics" and "loads"; "Aerodynamics" feeds into "mass" and "loads"; "loads" feeds into "CD" and "Structures"; "CD" feeds into "4" and "CL,mass"; "4" feeds into "5"; "5" feeds into "Performance"; "mass" feeds into "Structures"; "Structures" feeds into "CL,mass" and "Performance"; "Performance" feeds into "fuelFlow"; "fuelFlow" feeds into "Emissions"; "CO2,NOx" feeds into "Emissions". A red arrow points to the "Conv" button in the toolbar, and another red arrow points to the exclamation mark icon in the top right corner of the interface.

Note that all collisions are now resolved, and MDAx does not complain. However, it still indicates the existence of feedback connections. To resolve feedback, we need to use **Converger** nodes. Click the **Converger** button.



MDAx: MDO Workflow Design X +

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Add Converger

Converger Name: MDA

Notes:

Method: Gauss-Seidel Jacobi

Move the converger to change its position in the workflow.
Drag the handles on the blue lines to change which tools to wrap.

Position & Wrapping

```
graph TD; MDA((? MDA)) --- Aerodynamics[Aerodynamics]; MDA --- Structures[Structures]; MDA --- Performance[Performance]; Aerodynamics --- loads[loads]; Aerodynamics --- mass[mass]; Aerodynamics --- CD[CD]; Aerodynamics --- CLmass[CL,mass]; Structures --- CLmass; Performance --- fuelflow[fuel flow]; Performance --- Emissions[Emissions]; Aerodynamics --- CO2NOx[CO2,NOx];
```

Cancel Add

Set the converger name and method. Drag the blue border lines to set the convergence scope.

MDAx: MDO Workflow Design

Add Converger

Converger Name: MDA

Notes:

Method: Gauss-Seidel Jacobi

Move the converger to change its position in the workflow.
Drag the handles on the blue lines to change which tools wrap.

Position & Wrapping

The diagram illustrates a workflow design. At the top, two 'geometry' inputs feed into an 'Aerodynamics' tool. This is followed by a 'Structures' tool and a 'Performance' tool, each with their own inputs. A 'MDA' (Multi-Disciplinary Analysis) converger is positioned above the workflow, indicated by a blue box and a red arrow pointing to it. The 'MDA' converger wraps the 'Aerodynamics', 'Structures', and 'Performance' tools. The 'MDA' converger also has outputs labeled 'CD' and 'CL,mass'. The 'Performance' tool has an output labeled 'fuelFlow'. The 'Emissions' tool is at the bottom, receiving input from 'fuelFlow'. On the far left, there is a 'CO2,NOx' output. The right side of the interface shows MDAX v0.5.2 branding and various icons for file operations and help.

Since feedback only exists between two tools, we can wrap only those with the converger.



MDAx: MDO Workflow Design X +

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Simple E Initial workflow

Method Gauss-Seidel Jacobi

Move the converger to change its position in the workflow. Drag the handles on the blue lines to change which tools to wrap.

Position & Wrapping

```
graph LR; subgraph 1.0 [1.0, 1.3 → 1.1]; MDA[MDA]; end; subgraph 1.1 [1.1]; Aerodynamics[Aerodynamics]; end; subgraph 1.2 [1.2]; Structures[Structures]; end; subgraph 2 [2]; Performance[Performance]; end; subgraph 3 [3]; Emissions[Emissions]; end; MDA -- "geometry" --> Aerodynamics; MDA -- "mass" --> Structures; Aerodynamics -- "CD,CL" --> Structures; Structures -- "fuelFlow" --> Emissions; Aerodynamics -- "CO2,NOx" --> Emissions; Aerodynamics --- 4; Aerodynamics --- 5;
```

To define the variables that are checked for convergence, select convergence check variables below. Otherwise, all variables routed through the converger will be checked for convergence.

Convergence Check Variables	Variable	Actions
	<input checked="" type="checkbox"/>	<input type="button" value="Add"/>

Cancel Update

MDAx - Impressum | About MDAx

You can optionally add convergence check variables. These variables will be used to check convergence. If none are set, all exchanged variables will be checked for convergence. Click *Add*.

MDAx: MDO Workflow Design X +

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Simple Emissions

Initial workflow

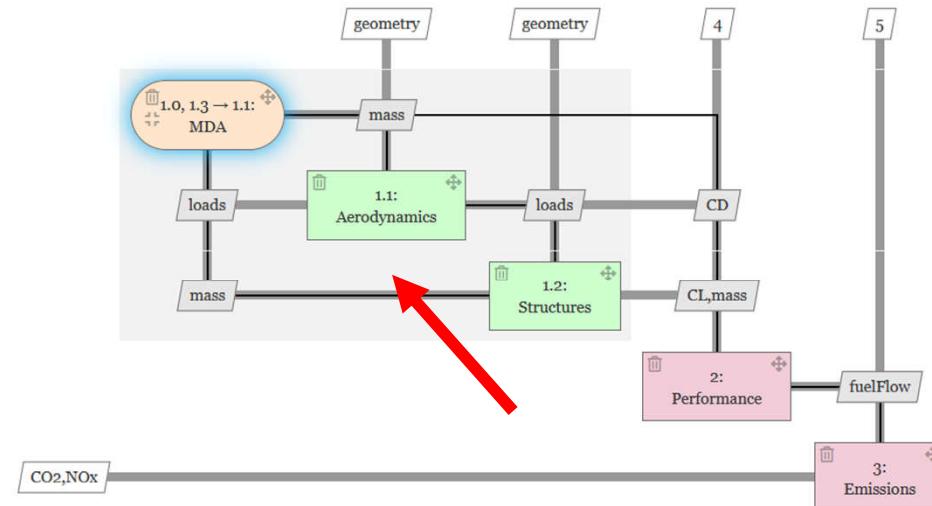
MDAx v0.5.2

Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Vars Base Schema

MDAx v0.5.2

The screenshot shows a workflow diagram titled "Simple Emissions" in the MDAx interface. The diagram consists of several nodes connected by arrows. At the top, two "geometry" nodes feed into a "mass" node. This "mass" node connects to a "loads" node, which then feeds into two parallel "Aerodynamics" and "Structures" nodes. Both of these nodes connect to a "CD" node. From the "CD" node, an arrow points to a "CL, mass" node, which then connects to a "Performance" node. The "Performance" node has an output labeled "fuelFlow". A feedback loop from the "Performance" node goes back to the "Aerodynamics" and "Structures" nodes. Finally, an output labeled "CO₂, NO_x" leads to a "3: Emissions" node. A red arrow points from the text in the slide to the connection between the "Aerodynamics" and "Structures" nodes.



The feedback connections among the wrapped tools are now rerouted through the converger.

MDAx also now indicates that there are no issues and the workflow is executable.



MDAx: MDO Workflow Design X +

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Simple Emissions

Initial workflow

MDAx v0.5.2

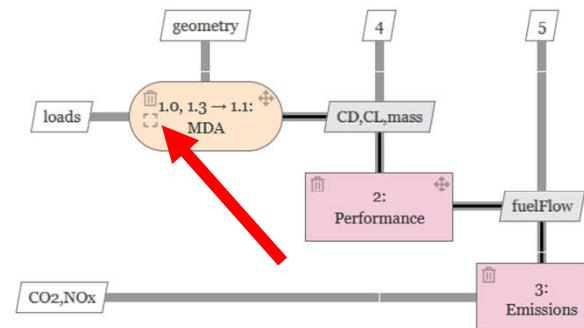
Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Vars Base Schema

MDAx v0.5.2

Opt DoE Conv f(x) Tool Tools Batch Sub Vars Base Schema

Vars Base Schema



Driver nodes such as a converger can be collapsed for a better overview.

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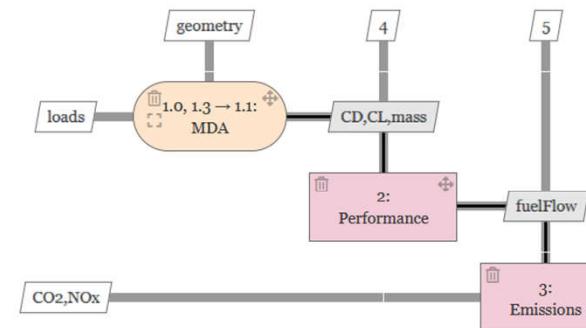
Simple Emissions

Initial workflow

Opt Conv Tool Tools Batch Sub Vars Base Schema

MDAx v0.5.2

The screenshot shows the MDAX interface with a workflow titled 'Simple Emissions'. The top navigation bar includes links for Admin, Literature, Language, Programming, Tools, Temp, and various system icons. Below the title, there's a toolbar with buttons for Opt, Conv, Tool (highlighted with a red arrow), Tools Batch, Sub, Vars, and Base Schema. The main area displays a workflow diagram with nodes: 'loads' (input), 'geometry' (input), '1.0, 1.3 → 1.1: MDA' (process), 'CD,CL,mass' (output), '4' (output), '5' (output), 'CO2,NOx' (input), 'Performance' (process), 'fuelFlow' (output), and 'Emissions' (process). The 'Emissions' node has an output labeled '3: Emissions'.



Besides tools, MDAX can also integrate mathematical functions. Click the *Add Math Function* button.

MDAx: MDO Workflow Design

Add Mathematical Function

Math Block Name: Objective

Notes:

1. Select variables to use as equation parameters, optionally giving them an alias
2. Select the output parent: all expression outputs will be children of this node
3. Enter the equations: use Python syntax, and use the previously entered aliases as variables

Equation Parameters	Variable	Alias	Actions
<input checked="" type="checkbox"/>		Alias	+

Output Parent Variable required

Child Variable Path required

Child Variable Path	Expression (Python)	Actions
Child variable name	= Expression (Python syntax, use available parameter aliases as variables)	+

Cancel Add

MDAx MDO Workflow Design Accelerator DLR

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Here, define the function name and select the equation parameters (if used).

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Add Mathematical Function

Math Block Name: Objective

Notes:

1. Select variables to use as equation parameters, optionally giving them an alias
2. Select the output parent: all expression outputs will be children of this node
3. Enter the equations: use Python syntax, and use the previously entered aliases as variables

Equation Parameters	Variable	Alias	Actions
	CO2	CO2	
	NOx	NOx	
	<input checked="" type="checkbox"/>	Alias	

Equation output will be written to variables in the *output parent*. It is possible to specify nested child variables using a / delimiter: "child/var" writes the value to var in child, which is located in the *output parent*.

Output Parent Variable required

Equations required

Child Variable Path	Expression (Python)	Actions
Child variable name	= Expression (Python syntax, use available parameter aliases as variables)	

Cancel Add

MDAx - Impressum | About MDAx



You can change parameter aliases by pressing the *Edit* button.

MDAx: MDO Workflow Design x +

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Simple E Initial workflow

Add Mathematical Function

Math Block Name: Objective

Notes:

1. Select variables to use as equation parameters, optionally giving them an alias
2. Select the output parent: all expression outputs will be children of this node
3. Enter the equations: use Python syntax, and use the previously entered aliases as variables

Equation Parameters	Variable	Alias	Actions
	CO2	CO2	[edit] [delete]
	NOx	NOx	[edit] [delete]
	<input checked="" type="checkbox"/>	Alias	[+]

Equation output will be written to variables in the *output parent*. It is possible to specify nested child variables using a / delimiter: "child/var" writes the value to var in child, which is located in the *output parent*.

Output Parent Variable required

Equations required

Child Variable Path: Child variable name

Expression (Python): = Expression (Python syntax, use available parameter aliases as variables)

Cancel Add

MDAx v0.5.2

al-impressum | About MDAx

Define the output parent...



The screenshot shows the MDAX MDO Workflow Design interface. A modal dialog titled "Select Output Node" is open. Inside the dialog, there is a tree view of a schema structure:

- schema
 - aircraft
 - mission
 - profile
 - emissions** (selected)
 - CO2
 - NOx

Below the tree view, there is a note: "Equation output will be written to variables in the *output parent*. It is possible to specify nested child variables using a / delimiter: "child/var" writes the value to var in child, which is located in the *output parent*".

At the bottom of the dialog, there are "Cancel" and "Select" buttons. Red arrows point from the text above to the "emissions" node and from the text below to the "Select" button.

...by selecting a branch (non-leaf) variable. Click Select.

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Simple E Initial workflow

Add Mathematical Function

Math Block Name: Objective

Notes:

1. Select variables to use as equation parameters, optionally giving them an alias
2. Select the output parent: all expression outputs will be children of this node
3. Enter the equations: use Python syntax, and use the previously entered aliases as variables

Equation Parameters	Variable	Alias	Actions
	CO2	CO2	[edit] [trash]
	NOx	NOx	[edit] [trash]
	[<input checked="" type="checkbox"/> Alias]		[+]

Equation output will be written to variables in the *output parent*. It is possible to specify nested child variables using a / delimiter: "child/var" writes the value to var in child, which is located in the *output parent*.

Output Parent Variable: /schema/mission/emissions [X] []

Equations required	Child Variable Path	Expression (Python)	Actions
	emissionIndex	= 2*CO2 + 3*NOx	[+]

Cancel Add

MDAx

Now define the variable name (output variable), the expression, and click the *plus* button.

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Simple E Initial workflow

Math Block Name: Objective

Notes:

1. Select variables to use as equation parameters, optionally giving them an alias
2. Select the output parent: all expression outputs will be children of this node
3. Enter the equations: use Python syntax, and use the previously entered aliases as variables

Equation Parameters

	Variable	Alias	Actions
	CO2	CO2	[Edit] [Delete]
	NOx	NOx	[Edit] [Delete]
<input checked="" type="checkbox"/>	Alias		[+]

Equation output will be written to variables in the *output parent*. It is possible to specify nested child variables using a / delimiter: "child/var" writes the value to var in child, which is located in the *output parent*.

Output Parent Variable: /schema/mission/emissions

Equations

	Child Variable Path	Expression (Python)	Actions
	emissionIndex	= 2*CO2 + 3*NOx	[Edit] [Delete]
	Child variable name	= Expression (Python syntax, use available parameter aliases as variables)	[+]

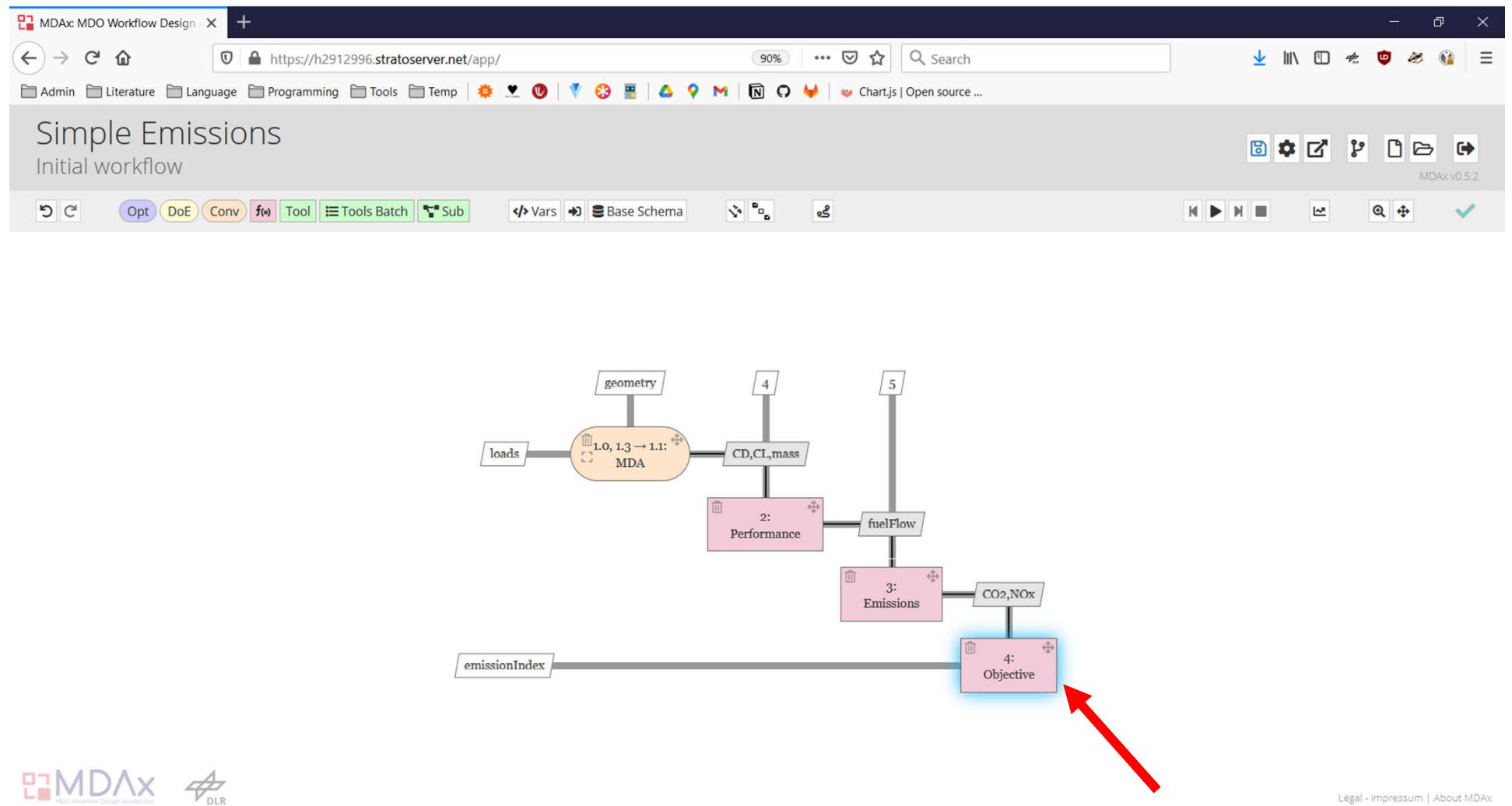
MDAx v0.5.2

Cancel Add

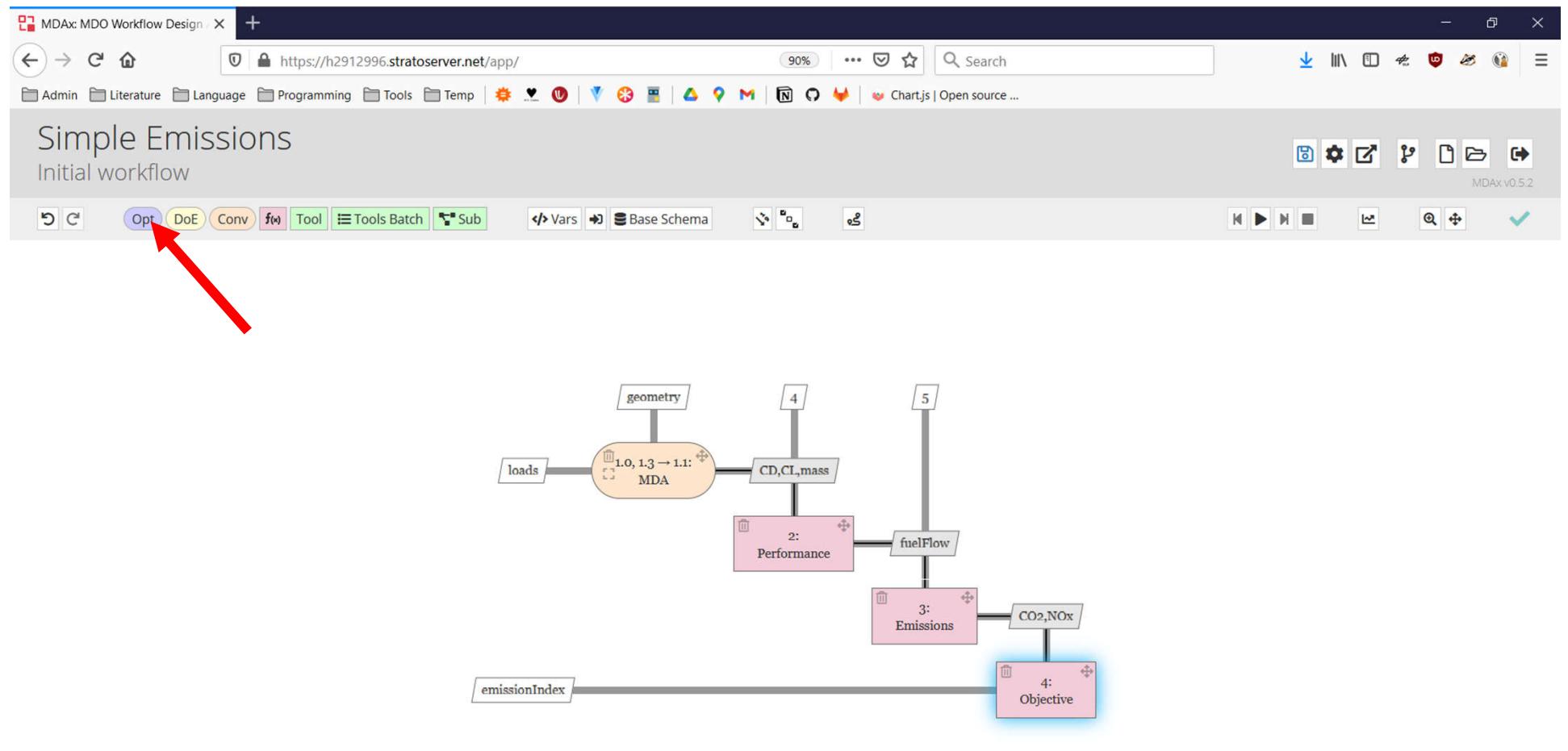
Impressum | About MDAx

Finally click Add.





The mathematical function now appears on the canvas, with appropriate input and output connections.



We can use this workflow to run an optimization. To do this, we can add an Optimizer node using the *Optimizer* button.

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Simple E Initial workflow

Add Optimizer

Optimizer Name: Optimizer

Notes:

Move the optimizer to change its position in the workflow. Drag the handles on the blue lines to change which tools to wrap.

Position & Wrapping

```

graph LR
    Optimizer((Optimizer)) --- MDA[1.0 -> 1.41 MDA]
    MDA --- mass1[mass]
    mass1 --- loads1[loads]
    loads1 --- mass2[mass]
    mass2 --- Aerodynamics[Aerodynamics]
    Aerodynamics --- loads2[loads]
    loads2 --- Structures[Structures]
    Structures --- CLmass[CL.mass]
    CLmass --- Performance[Performance]
    Performance --- fuelFlow[fuelFlow]
    fuelFlow --- Emissions[Emissions]
    Emissions --- CO2[CO2]
    CO2 --- NOx[NOx]
    NOx --- Objective[Objective]
    
```

Only variables that are *exclusively* input to the wrapped functions are available for selection as design variables. If the desired design variables are not available for selection, carefully check the I/O of the wrapped functions to make sure the design variables are not written to.

Cancel Add

Similar to the converger, we can drag the blue line to define the tools that are wrapped by the optimizer.

MDAx: MDO Workflow Design X +

https://h2912996.stratoserver.net/app/

Admin Literature Language Programming Tools Temp ... Search

Simple E Initial workflow

emissionIndex

2: Performance

fuelFlow

3: Emissions

CO, NOx

4: Objective

Only variables that are exclusively input to the wrapped functions are available for selection as design variables. If the desired design variables are not available for selection, carefully check the I/O of the wrapped functions to make sure the design variables are not written to.

Design variabels are the parameters varied by the optimizer to optimize the design.

Design Variables required	Variable	Lower Bound	Nominal Value	Upper Bound	Actions
	<input type="checkbox"/>	Lower <input type="button"/>	Nom <input type="button"/>	Upper <input type="button"/>	<input type="button"/>

Objectives are the parameters that should be minimized in order to produce a "better" design.

Objectives required	Variable	Actions
	<input type="checkbox"/>	<input type="button"/>

Constraints limit the feasible design space in which the optimizer can search for an optimal design.

Constraints	Variable	Type	Reference Value	Actions
	<input type="checkbox"/>	<=	0	<input type="button"/>

Cancel Add

Select the design variables and objectives and add them using the *plus* buttons. You can optionally set the bounds and nominal values for each design variable.

MDAx: MDO Workflow Design X +

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Simple E Initial workflow

Only variables that are *exclusively* input to the wrapped functions are available for selection as design variables. If the desired design variables are not available for selection, carefully check the I/O of the wrapped functions to make sure the design variables are not written to.

Design variables are the parameters varied by the optimizer to optimize the design.

Design Variables

	Variable	Lower Bound	Nominal Value	Upper Bound	Actions
	climbRate				<input type="checkbox"/> <input type="button" value="Delete"/>
	designSpeed				<input type="checkbox"/> <input type="button" value="Delete"/>
	geometry				<input type="checkbox"/> <input type="button" value="Delete"/>

Objectives are the parameters that should be minimized in order to produce a "better" design.

Objectives

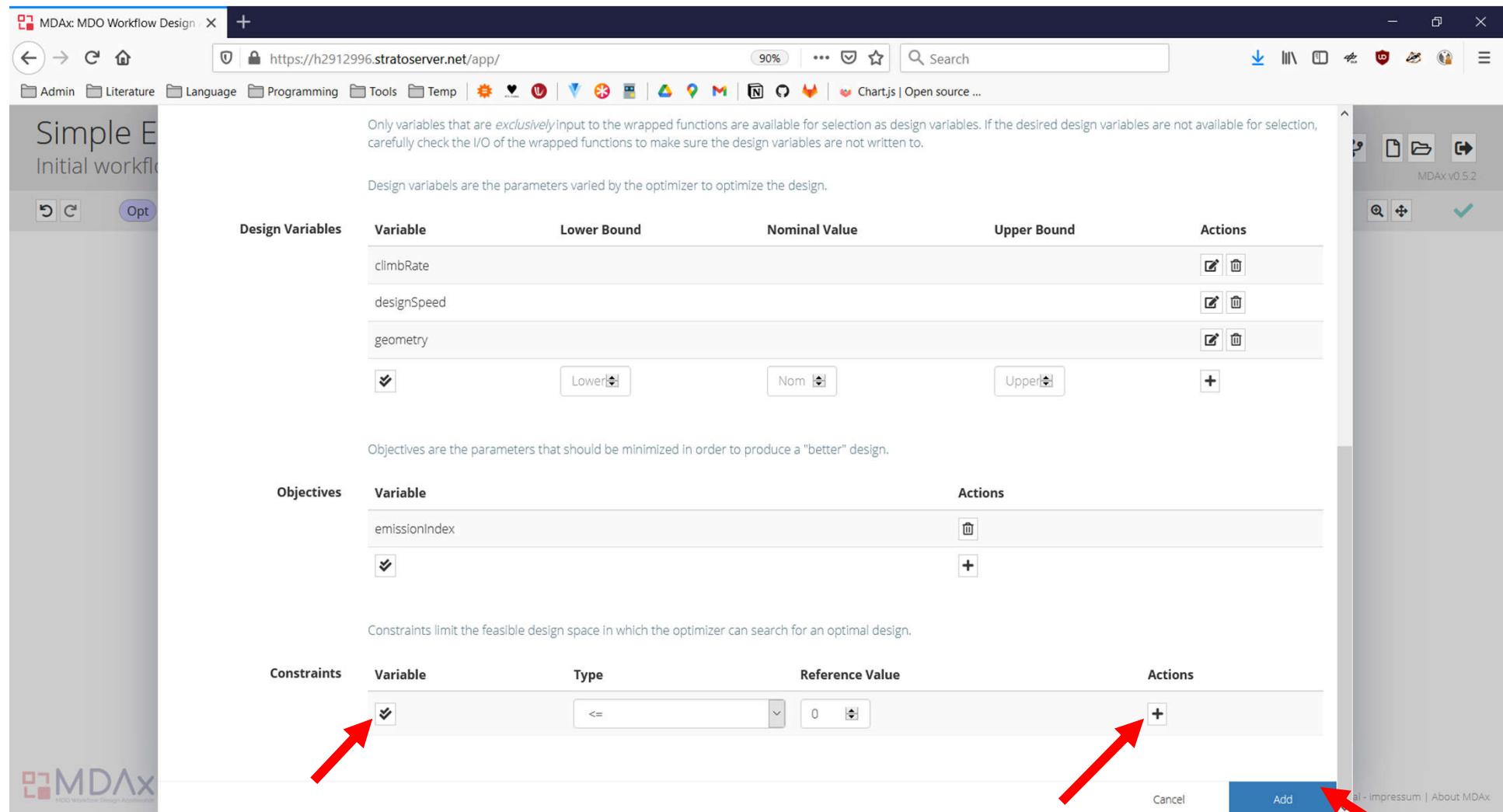
	Variable	Actions
	emissionIndex	<input type="button" value="Delete"/>
		<input type="button" value="Add"/>

Constraints limit the feasible design space in which the optimizer can search for an optimal design.

Constraints

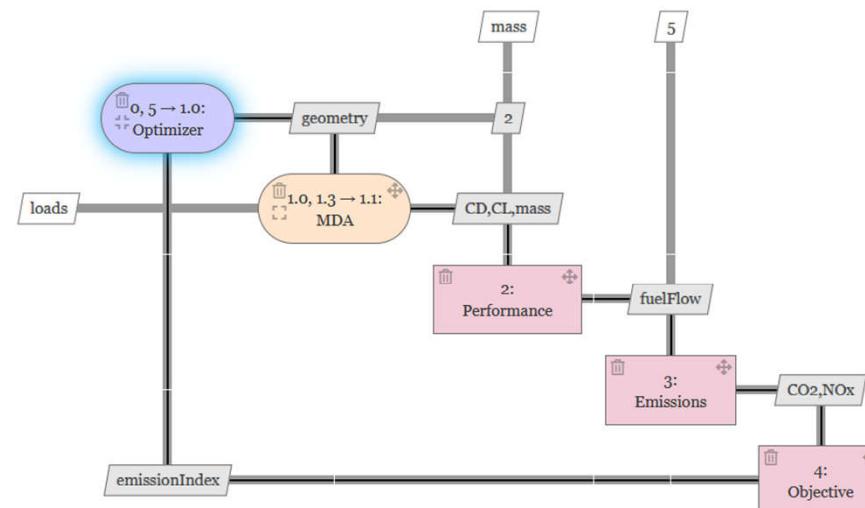
	Variable	Type	Reference Value	Actions
	<input checked="" type="checkbox"/>	<=	0	<input type="button" value="Add"/>

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You can optionally select and add design constraints. Once finished, click Add.

The screenshot shows the MDAx: MDO Workflow Design application window. The title bar includes the application name and a plus sign icon for opening new tabs. The toolbar features various icons for file operations like back, forward, search, and download, along with icons for different tools and components. A navigation bar below the toolbar lists categories such as Admin, Literature, Language, Programming, Tools, Temp, and several icons representing specific tools or models. The main content area displays a title 'Simple Emissions' and a subtitle 'Initial workflow'. On the right side of the interface, there is a toolbar with icons for saving, settings, and other workflow management functions. A red arrow points to the gear icon in this toolbar. The bottom of the screen shows a footer with the version 'MDAx v0.5.2' and a series of small icons.

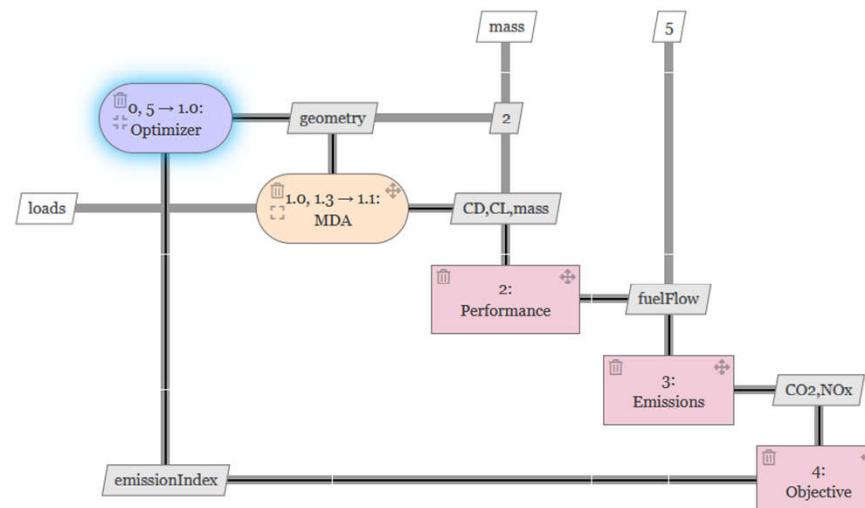


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The optimizer is now present on the canvas. To save this workflow model, click the **Save** button and download the model file.



The screenshot shows the MDAx: MDO Workflow Design application window. The title bar reads "MDAx: MDO Workflow Design". The main content area displays a "Simple Emissions" workflow titled "Initial workflow". On the right side of the workflow, there is a toolbar with several icons: a gear (Settings), a magnifying glass (Search/Filter), a checkmark (Validation), a document (Documentation), a folder (File Manager), and a right-pointing arrow (Next Step). A red arrow points from the bottom right towards the search/filter icon. At the bottom of the screen, there is a navigation bar with various buttons like Opt, DoE, Conv, Tool, Tools Batch, Sub, Vars, Base Schema, and several icons for file operations (Save, Open, Print, etc.). The status bar at the bottom right indicates "MDAx v0.5.2".



MDAx

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To export this workflow into other formats, click the *Export* button...



MDAx: MDO Workflow Design X +

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Simple E

Initial workflow

XDSM (PDF) XDSM (SVG) Interactive XDSM (HTML) MDAx Project

RCE (local) RCE (CPACS) RCE (Brics) CMDOWS Tool I/O

Workflow Input

MDAx v0.5.2

MDAx MDO Workflow Design Accelerator

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The screenshot shows the MDAX interface with a central panel titled 'Export: Simple Emissions' and 'Initial workflow'. It displays various export formats: XDSM (PDF), XDSM (SVG), Interactive XDSM (HTML), MDAx Project, RCE (local), RCE (CPACS), RCE (Brics), CMDOWS, and Tool I/O. Below these is a large 'Workflow Input' section with a large right-pointing arrow. The left sidebar shows a tree view of the workflow and the MDAX logo. The top navigation bar includes links for Admin, Literature, Language, Programming, Tools, Temp, Chart.js, and Open source ...

...and select the format you want to export it to. For visualization, use the *PDF*, *SVG* or *interactive HTML* export. For execution, use the *RCE* or *CMDOWS* exports.

For more MDAx examples, check out the following repos:

- <https://github.com/andreas-pr-dlr/mdax-sellar>
- <https://github.com/andreas-pr-dlr/mdax-emissions>
- <https://github.com/andreas-pr-dlr/mdax-hep>
- <https://github.com/andreas-pr-dlr/mdax-ssbj>

Access the app via <https://mdax.agile4.eu/app/>.

